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Land Use and Land Cover Change Detection In Ilorin, Nigeria, Using Satellite Remote Sensing

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Abstract
In this paper, land use and land cover change detection of Ilorin and its immediate environs for three (3) periods of twenty-eight (28) years was conducted. Since several advantages are associated with macroscopic and multi-temporal observation, four satellite images of different dates (1976, 1987, 1994 and 2004) were interpreted and analyzed to extract the detailed information for identification of the changes. To obtain the changes in the classes, the traditional approach of post classification comparison was followed. Observed consequences of city growth and land use and land cover changes were identified with a view to drawing the attention of relevant stakeholders in the urban environmental sector to the need to severely curtail those of the changes that are unwarranted. The successful preparation of change maps, once again, buttress the usefulness of satellite remote sensing in detail mapping and land use change detection studies. The negative effects of changes should always be adequately addressed to reduce their impact to the barest minimum on humans and environment.

Key words: Country side, Synoptic view, Ancillary Data, Revisit Capability, Nigeria Sat-1

1. Introduction

It is not only the urban centres that are undergoing dramatic changes worldwide, but the country side, forests, coasts, the interior regions etc of all parts of the world. All the changes are however, induced by both human activities such as shifting cultivation, animal grazing, increase in population growth and natural processes (especially climatic). Since the needs of humans are becoming more unlimited, the land use/abuse changes are also becoming more limitless. The former is a function of the latter. A consequence of these changes is not only impacting on humans but also on other living species (e.g. vegetation). There could also be a highly dramatic loss of habitat for wildlife. To put it in another way, deforestation and/or devegetation disperses bush animals beyond regions that are largely not within the reach of humans.

Data from satellite images, with its synoptic view of large area under uniform illumination and revisit capabilities amongst other benefits, can offer possibilities for the land use change patterns (Aldrich, 1975). Modeling these changes through the use of remote sensing techniques is critical/crucial for formulating effective environmental policies and management strategies (Kuleli, 2005).

On the basis of the foregoing, this paper employs the technique in detecting changes in land use/land cover whilst the second problem involves estimating the areal extent of the changes. The paper also addresses the consequences arising from the observable changes in land use patterns, an appreciation of which could assist the relevant planning authorities to promptly and easily counter the adverse effects of the changes.

2. Study Area

Ilorin city is located in the central geo-political zone of Nigeria. It is one of the largest indigenous urban centres in the region. It was a provincial headquarters for a period of about forty-five years (Onokerhoraye,

1982). Moreover, with the creation of Kwara State in 1967, Ilorin was selected as the capital city of the state (Fig 1).Additionally; it also served as the headquarters of Ilorin Division as well as Ilorin Emirate Council. Presently, the latter (i.e.Ilorin Emirate) is made up of five local government areas viz, Asa, Moro, Ilorin East, South and West. These administrative status, which it assumed over the years, have greatly influenced the urban development and expansion of the study area.

Ilorin has experienced a rapid growth in the number of medium size and large commercial establishments available over the years. A substantial increase in the number of manufacturing and construction industries, which have sprouted up

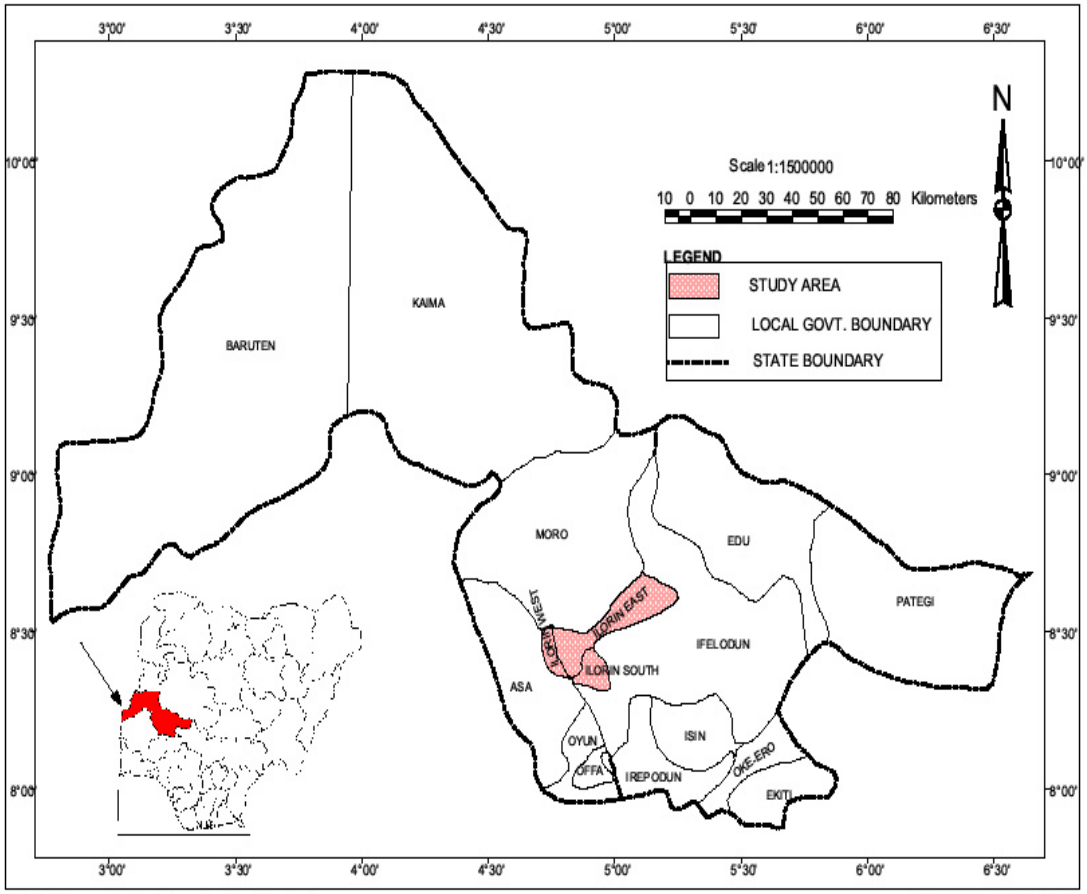

Fig. 1: Kwara State Showing the Study Area
Source: Oloru (1998)

is also an index of structural changes in the city of Ilorin. The establishment of educational institutions in the study area such as the University, Polytechnic and other related tertiary institutions and many secondary schools has yet been another contributory factor towards the growth of Ilorin. The physical expansion of the city in the long run, inevitably leads to a gradual increase in population of the study area. As Adedibu et al (1998) put it; the population of Ilorin increased astronomically, which goes on to affect the land area of the city.

Human activities such as farming and logging at the peripheral part of the study area drive changes in land cover. Shifting cultivation in particular, has a modifying impact on the guinea savanna vegetation of the area. Devegetation therefore, frequently results in soil erosion. The favourable synoptic view of satellite however, makes it possible for this study to extend its scope in terms of areal coverage to the outskirts of the city.

3. Data Sources and Methodology

Landsat MSS of 1976, Landsat TM of 1987, Spot XS of 1994 and Nigeria Sat-1 of 2004 were sourced for interpretation and analyzed in order to obtain the required data for this work. Ancillary data such as topographic, street guide, land use and infrastructure maps were used as base maps. There was also an intensive ground truth exercise. The images were however obtained from the Remote Sensing/GIS Department, Federal Ministry of Agriculture and Rural Development Abuja, Nigeria and the National Space Research Development Agency (NSRDA), also in Abuja, while the maps were sourced from the Federal Surveys in Kaduna and Ilorin. Some features of the Landsat satellite images are presented in

Table 1.

TABLE 1: Some Features of the Landsat Images Used in the Study

Satellite	Sensor	Band	Spatial resolution	Acquisition date
Landsat 2	Multispectral Scanner (MSS)	4	79	Nov. 1976
Landsat 5	Thematic Mapper (TM)	7	30	Jan. 1987
Sport 3	High Resolution Visible (HRV)	3	20	Dec. 1994
Landsat 1	Thematic Mapper (TM)	3	32	Not available

Source: Compiled by the Authors.

Most change detection techniques fall into five general categories: manual, write function memory insertion, image enhancement, multi-date data classification and comparison of two independent land cover classifications (Kuleli, 2005; Masi, 1999; Jenson, 1996). In this study, the traditional approach of post classification comparison, which aims at establishing the difference between the classified images of two different dates, is followed in producing the four change maps. Indeed, according to Howarth and Wickware (1981), this procedure does not only allow areas of no change to be identified, but in areas where change has occurred, the nature of the change can be determined. Additionally, selective grouping of classification results allows the analyst to observe any subset of changes, which may be of interest (Singh, 1989).

For clarity of expression, analysis of change detection was carried out through the use of Arcview. In the first instance, digital layers of land use/ land cover classes for the years under focus (i.e. 1976, 1987, 1994 and 2004) were obtained. The areal extent of each class was then delineated. Secondly, the layers were over laid and the results (were) displayed, which allowed comparison to identify changes and the magnitudes of the changes that were involved.

It however, needs to be clarified that each of the composite change maps depicts only the changes that involve just a single class for the years 1976, 1987, 1994 and 2004. For instance, while the first composite change map (fig 2) shows the water bodies for the dates 1976, 1987, 1994 and 2004, fig 3 indicates the changes in vegetal cover for the four years. Finally, maps were printed by A3 colour printer model Hp deskjet 1280.

Consequences of land use/land cover changes were determined through a well structured questionnaire administration and a carefully, well conducted oral interview. Ground truth (field check) exercise was undertaken to aid in the analysis and interpretation of the satellite images. Areas and/or objects like the Emir's palace, university and polytechnic campuses, saw-mill, Shao settlement, Asa and Agba dams etc were established on the images. Some elements of image interpretation such as shape, size, site and tone were of great assistance in the interpretation process. Familiarity of the researcher with the study area greatly assisted in the interpretation process. It also greatly eased out the complications associated with
administration of the structured questionnaire and the conduct of the oral interview. More so, the ability of the researcher to communicate in the local language (Yoruba) was an added advantage in this direction.

4. Results and Discussion

In this study, the imageries of 1976, 1987, 1994 and 2004 were evaluated and the obtained data in respect of the involved changes are summarized under three periods as follow:

4.1. Changes in Land Use/ Land Cover, 1976-1987

During this period, the built-up area increased by 14.353km^2 (23.89%) with an annual change of 1.30km^2.The cultivated area also increased by 83.381km^2(12.49%).These increases were gained from the vegetal cover. Vegetal cover thus, lost as much as 98.233km^2, with an annual change of -8.93km^2. The water body recorded the least annual change of 0.05km^2, which translates into 5.08% (Table 2).

Table 2: Land Use/Land Cover Change Statistics, 1976-1987

S/N	Land Use/Land Cover Class	Area (km^2) 1976	1987	Increase(+) Decrease (-)	Percentage Change	Annual Change
1.	Built-up Area	45.7434	60.09628	+ 14.353	23.89	1.30
2.	Cultivated Area	584.3402	667.722	+83.381	12.49	7.58
3.	Vegetal cover	121.7874	23.554	-98.233	417.05	-8.93
4.	Water Bodies	9.3133	9.8115	+0.4982	5.08	0.05

Source: Authors' Data Analysis

4.1.1. Changes in Land Use/Land Cover, 1976-1987

It is glaring from Tables 2 and 3 that built-up area appreciated from 14.35288km^2 during the 1976 – 1987 periods to 15.7199km^2 in the 1987 – 1994 period. This is an indication of gradual city expansion. Other types of changes that occurred during the 1987- 1994 period are also depicted on the change maps (figs 2-5)

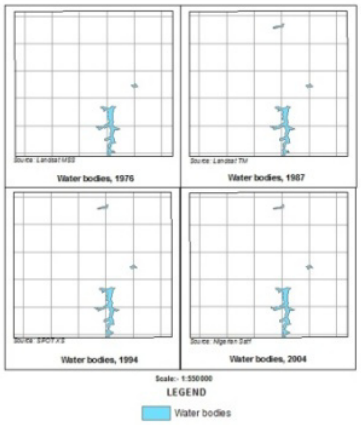

Fig 2: Change in water Bodies 1976-2004

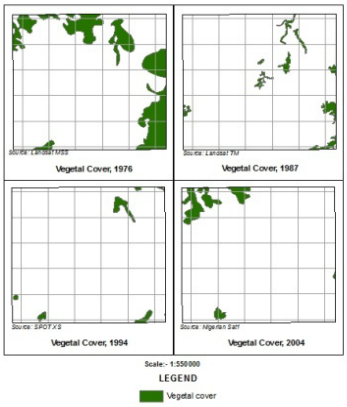

Fig 3: Change in Vegetal Cover 1976-2004

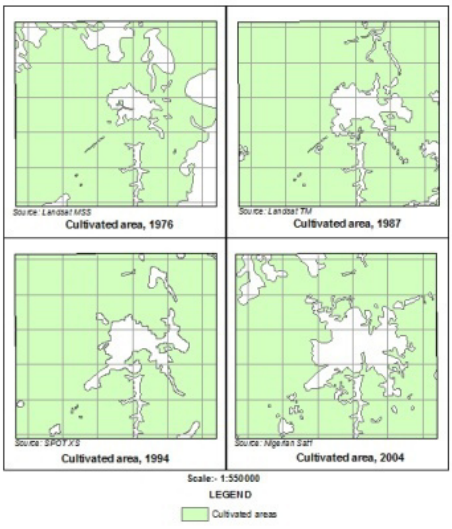

Fig 4: Change in Cultivated Area 1976-2004

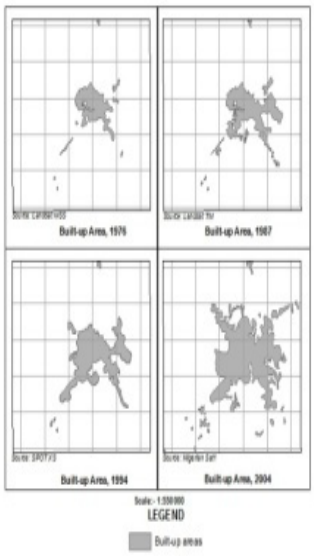

Fig. 5: Change in Built-up Area 1976-2004

Table 3: Land Use/Land Cover Change Statistics, 1987 - 1994

S/N	Land Use/Land Cover Class	Area (km^2) 1987	1994	Increase(+) Decrease (-)	Percentage change	Annual change
1.	Built-up Area	60.096	75.8159	+15.7199	26.158	2.25
2.	Cultivated Area	667.722	663.089	- 4.633	7.71	-0.66
3.	Vegetal cover	23.554	12.469	- 11.086	88.90	-1.58
4.	Water Bodies	9.811	9.811	0.00	0.00	0.00

Source: Authors'Data Analysis

4.1.2. Changes in Land Use/Land Cover, 1987 – 1994

The built-up area increased by 50.6451km^2 (66.80% change) with an annual change of 5.06km^2. The vegetal cover gained 18.953km^2 (60.32% change) of land area. These increases caused the cultivated area to decrease by 69.598km^2 (Table 4). The gain trends are also graphically portrayed in figure 6.

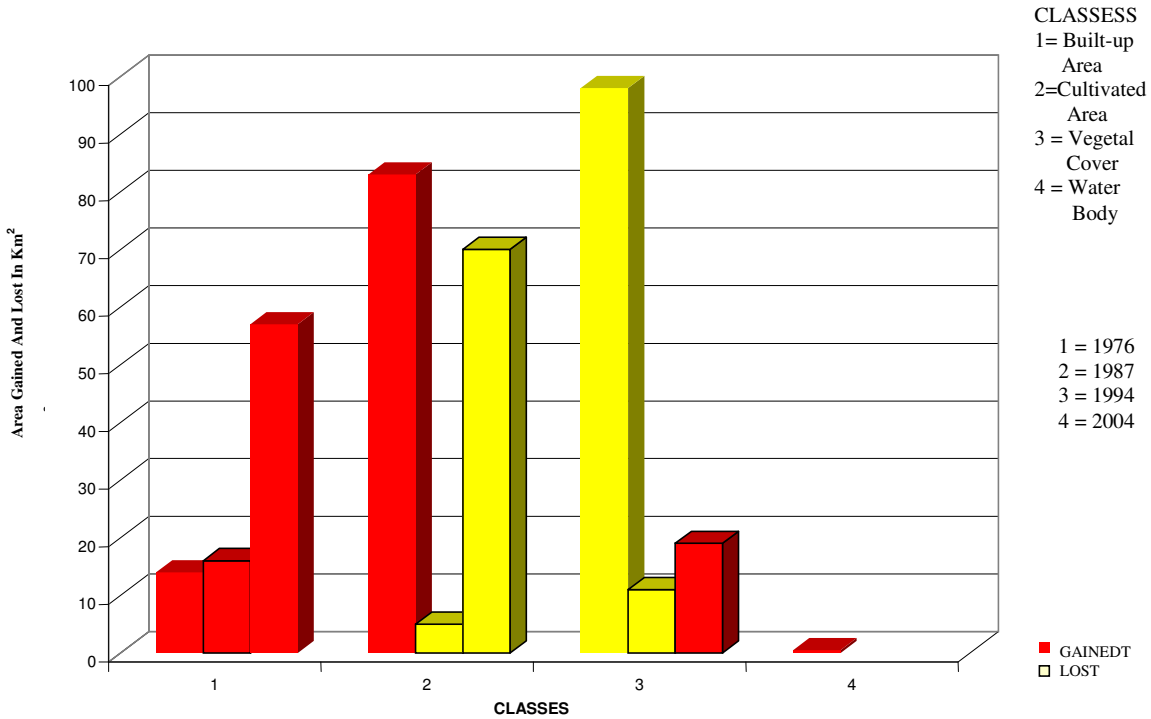

Figure 6: Land Use Changes (Gained/Lost) From 1976 – 2004
Source: Author's Data Analysis.

The results of the analysis indicate that the main direction of change during the period 1994 – 2004 is the conversion of cultivated area to both built-up area and vegetal cover classes. The increases in the areal coverage of the built-up class explain why the cultivated land and vegetal cover have been pushed to the outskirts of the city of Ilorin.

Table 4: Land Use/Land Cover Change Statistics, 1994 - 2004

S/N	Land Use/Land Cover Class	Area (km^2) 1994	2004	Increase(+) Decrease (-)	Percentage Change	Annual Change
1.	Built-up Area	75.8159	126.460	+50.6451	66.80	5.06
2.	Cultivated Area	663.087	593.489	-69.598	10.40	-6.96
3.	Vegetal Cover	12.469	31.422	+18.953	60.32	1.80
4.	Water Bodies	9.811	9.811	0.00	0.00	0.00

Source: Authors' Data Analysis

4.1.3. Consequences of the City Growth and Land Use and Land Cover Changes

A good number of the respondents and/or interviewees maintained that the changes in the classes over the 28 (1976 – 2004) years under review have had positive and negative effects on humans and the environment. For instance, 620 (31%) of the respondents were of the view that the city growth has brought about the availability of cheap labour in the study area. Several other positive effects are contained in fig 7. On the other hand, some of the identified basic negative aftermaths of the changes include pressure on land (92.46%); deforestation (281:14.0%) and lack of employment (130:6.5%). Others are reflected in Table 5.

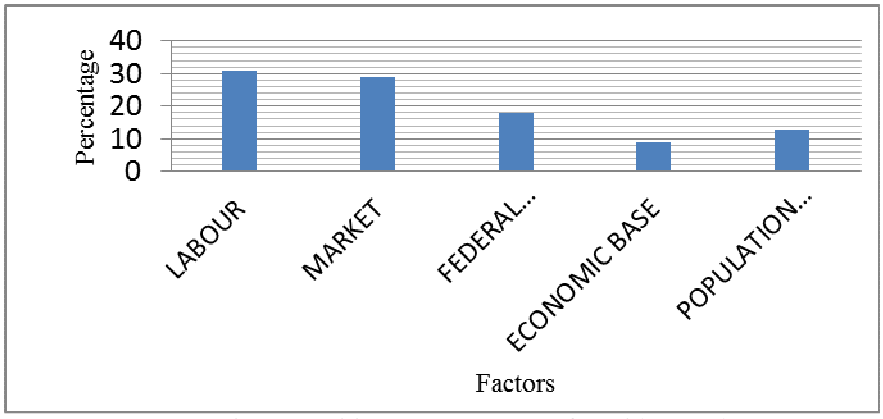

Fig. 7: Positive Consequences of Rapid Growth
Source: Author's Field Work

Table 5: Respondents Rating of Adverse Effects of the Growth of Ilorin

Adverse Effects	Frequency	Percent	Commulative Percent
Farmlands are getting further away from the city	338	16.9	16.9
Countryside farmers loss farm plots to physical development	297	14.8	31.7
Erosion	200	10.0	41.6
Deforestation	281	14.0	55.7
Pollution	105	5.2	60.9
Pressure on Land	92	4.6	65.5
Infertility of land	140	7.0	72.5
Scarcity of firewood	59	2.9	75.4
Lack of accommodation	147	7.3	82.7
Employment	130	6.5	89.2
Infrastructure	60	3.0	92.2
Exorbitant rent	49	2.4	94.6
General high cost of living	70	3.5	98.1
Insecurity due to crime and social vices	37	1.8	100
Total	**2005**	**100**	

Source: Authors' Field work

The consequences of city growth and changes in land use/ land cover in the study area have been a mixed blessing. This is in the sense that what some respondents/interviewees consider as advantages are perceived as disadvantages by some others. Nevertheless, it is pertinent to note that city growth and land use/ land cover changes are dynamic in nature, which can never be halted. Therefore, necessary steps should always be taken to reduce the impact of the negative effects (of the changes) on humans and the environment to the barest minimum. Those mitigating measures need to be pursued with more vigour commensurate with the rate of growth and the changes taking place. This can be done through adequate planning and development control to safeguard the well- being of society.

5. Conclusion

The main concern of the study has been to first, detect changes in land use and land cover of Ilorin and its immediate environs and secondly, to estimate the areal extent of the changes. This is with a view to providing required information, especially about the state of development and the nature of changes that

might have occurred, such information would be found useful in formulating effective environmental policies and management strategies. The paper also probed into the consequences of the growth recorded in city size and the derived changes. This would equip urban/environmental planners with relevant data that would enable them to promptly curtail the adverse effects.

Some of the after math of the growth and changes in the land use pattern include the mounting pressure on the existing housing stock (accommodation) and shrinking employment opportunities due to incessant influx of people into the city. An all encompassing panacea to the aftermath of the changes is that the management component of the process should always proceed with more vigour commensurate with the rate at which changes are taking place in the study area.

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